2.0 PRIORITIZATION OF BASINS

One objective of the Estero Bay Watershed Study was to assign priority to watershed tertiary basins in terms of the basins' potential to contribute to problems in the watershed and Estero Bay proper. The Basin Prioritization Report (Volume C of this series) evaluates and ranks the watershed tertiary basins. The following is a discussion of basin prioritization as it relates to the choice of watershed management options and the locations where these management tools should be implemented.

2.1 Basin Priority Objectives

The Water Management District has identified several, key evaluation-criteria for prioritizing impacts within and management strategies for the Estero Bay Watershed. These key criteria are:

- urban runoff discharge;
- agricultural runoff discharge;
- total suspended solids (TSS) loading;
- total nitrogen loading;
- total phosphorus loading; and
- wastewater and industrial discharge.

An objective of the Estero Bay Watershed Study was to estimate values for each of these criteria in sub-units of the watershed. Each secondary basin within the Estero Bay Watershed contains several sub-basins or tertiary basins. The Basin Prioritization Report addresses the criteria above by evaluating and ranking the watershed tertiary basins according to their potential as sources of:

- excess freshwater discharge (hydraulic loading or runoff),
- nutrient loading (total nitrogen and total phosphorous), and
- sediment loading (total suspended solids).

Values for an additional criterion, "wetland area at risk," were also estimated for each of the tertiary basin. Rapid growth and urbanization create the potential for not only changes in runoff and nutrient and sediment loading, but also for wetland losses through filling, excavation, drainage, and other alterations.

The emphasis of the basin prioritization task was on screening. The loading and wetland area at risk estimates were designed to be unbiased, relative-values that could support valid comparisons of secondary and tertiary basins. These relative values for each criterion were not developed to provide absolute estimates of discharge and loadings to the bay. Absolute estimates are part of a task to be undertaken by the modeling effort that will follow the Estero Bay and Watershed Assessment. The relative rankings were created to determine which tertiary basins are of high concern or high priority with respect to each criterion.

The basin prioritization study delineated nine secondary-basins within the watershed. Figures 1-1 and 1-2 are maps showing the locations and identifying numbers of these secondary basins. The study also delineated sixty-two tertiary basins within these secondary basins.

Relative rankings of the tertiary basins are divided into three groups, with the top 25% of the basins (the basins with the highest potential loadings per unit area or largest areas of wetlands at risk) designated as **high impact**, or priority, basins. The middle 50% of the basins are designated as **medium impact** basins, and the lowest 25% are designated as **low impact** basins.

2.2 Urban Runoff Discharge

Urban development has changed the landscape within the study area, resulting in changes to the physical manner in which runoff responds to rainfall. Replacement of wetlands and forests with impervious surfaces, such as asphalt pavement, rooftops, and concrete sidewalks, increase runoff rates from the land surface. This will contribute to excessive freshwater-discharges to the estuary observed during periods of high rainfall. Stormwater management systems (specific to individual projects) have been constructed and continue to be constructed within the study area in an effort to ameliorate the impacts of these changes to the land surface. In this study's ranking effort, these stormwater management systems were assumed to be uniformly distributed among the tertiary basins. In reality, stormwater management systems are probably less prevalent in older urban-development areas.

The Basin Prioritization Report assigned relative ranks to tertiary basins according to each basins's estimated total-annual urban-runoff discharge (summed across months). Table 2.1 lists area-weighted relative-ranks for urban-runoff discharge.

Unweighted rankings provide important information about runoff budgets for the watershed. However runoff and loading per unit area are more important than total runoff and loading when evaluating management options. "Per unit area" values convey information on intensity of runoff or loading that is important to the choice and siting of management options.

The area-weighted rankings of the tertiary basins within the Estero Bay Watershed show that three of the top five basins are in the Hendry Creek secondary basin (tertiary basins 6, 9, and 10) . Other

highly ranked basins include tertiary basin 4 in the Mullock Creek secondary basin and tertiary basins 4 and 1 in the Ten-Mile Canal secondary basin.

The results of the weighted analysis indicate that priority basins for urban runoff discharge are predominantly in the Ten-Mile Canal and Hendry Creek secondary basins. The Imperial River, Cow Creek, and Mullock Creek secondary basins also contain priority tertiary basins. The Ten-Mile Canal secondary basin discharges into the Mullock Creek secondary basin, and the Mullock Creek and Hendry Creek secondary basins share a common outfall location in Estero Bay. Taken as a unit, this complex of basins discharging into Estero Bay through Mullock Creek is the most important priority basin (in terms of urban runoff) in the watershed.

Table 2.1. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for area-weighted urban runoff discharge.

Secondary Basin	Tertiary Basin (TB)	Area (acres)	% Urban Land Use	% Agricultural Land Use	Area-weighted Urban Runoff (acre-feet/yr)/acre	Rank
Hendry Creek	6	449	63	7	1.76872	1
Mullock Creek	4	3596	81	7	1.70483	2
Ten-Mile Canal	4	153	67	0	1.63033	3
Hendry Creek	10	2459	59	0	1.53293	4
Hendry Creek	9	517	67	0	1.47858	5
Ten-Mile Canal	1	129	67	0	1.40605	6
Cow Creek	2	1864	61	0	1.31074	7
Hendry Creek	8	863	66	7	1.28883	8
Imperial River	1	3464	61	0	1.2763	9
Estero River	4	124	64	0	1.23072	10
Cow Creek	4	132	74	0	1.16561	11
Ten-Mile Canal	7	404	47	0	1.06851	12
Ten-Mile Canal	9	1266	53	24	1.03585	13
Imperial River	5	202	63	0	1.0033	14
Imperial River	3	1988	58	7	0.97173	15
Ten-Mile Canal	11	2569	42	12	0.89831	16

2.3 Agricultural Runoff Discharge

Agricultural development also changes the natural landscape that preceded it. Like urban development, agricultural development has changed the way the watershed's hydrologic system responds to rainfall. Replacement of rangeland, forests, and wetlands with relatively open pastureland and well drained citrus and vegetable croplands leads to increased runoff rates from the land surface. Like those for urban impervious land surfaces, these increased runoff rates contribute to excessive freshwater-discharges to the estuary during periods of high rainfall.

The Basin Prioritization Report evaluated tertiary basins in terms of their potential to generate agricultural runoff. The tertiary basins were assigned relative ranks according to estimated, total-annual agricultural runoff discharge. Table 2.2 presents the area-weighted relative ranks for agricultural runoff discharge.

When basins are not weighted by their areas, the top ranked Estero Bay Watershed tertiary basins for agricultural runoff include three basins located in the eastern portion of the watershed. These basins, Imperial River - 6, Estero River - 8, and Six-Mile Cypress Slough - 4, are larger than 18,000 acres and have more than 20% of their land used for agricultural purposes.

The area-weighted rankings for two of the top three tertiary basins within the Estero Bay Watershed in the unweighted rankings are also in the top 25% of the tertiary basins in the area-weighted rankings. Imperial River - 6 and Estero River - 8 are ranked fourth and fifth, respectively, in the area-weighted rankings of agricultural runoff. Ten-Mile Canal - 8 and Six-Mile Cypress Slough -5, first and second in the area-weighted rankings, both have runoff of more than 0.5 acre-feet/yr/acre.

2.4 Total Suspended Solids Loading

Agricultural and urban development have likely led to increased suspended solids loading to the Estero Bay estuary. Increased suspended solids loading can increase turbidity and muck deposition in the estuary. The Basin Prioritization study estimates total suspended solids (TSS) loading for each tertiary basin

The tertiary basins were assigned relative ranks according to estimated total annual total suspended solids loading. Table 2.3 shows the area-weighted relative ranks for total suspended solids loading in tertiary basins.

Table 2.2. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for area-weighted agricultural runoff discharge.

Secondary Basin	Tertiary Basin	Area (acres)	% Urban Land Use	% Agricultural Land Use	Area-weighted Agricultural Runoff (acre-feet/yr)/acre	Rank
Ten-Mile Canal	8	1441	11	42	0.60592	1
Six-Mile Cypress Slough	5	653	14	29	0.51273	2
Imperial River	4	4695	30	37	0.4629	3
Imperial River	6	41568	3	25	0.37922	4
Estero River	8	27647	16	27	0.37194	5
Estero River	6	7467	15	27	0.33781	6
Ten-Mile Canal	6	1728	44	28	0.33523	7
Six-Mile Cypress Slough	6	1968	13	27	0.33106	8
Ten-Mile Canal	9	1266	53	24	0.32244	9
Six-Mile Cypress Slough	4	18354	20	23	0.29188	10
Estero River	7	248	46	24	0.28643	11
Hendry Creek	5	1874	27	29	0.28084	12
Estero River	5	2460	41	17	0.23157	13
Six-Mile Cypress Slough	1	8345	29	15	0.20212	14
Estero River	3	2699	14	15	0.18168	15
Ten-Mile Canal	11	2569	42	12	0.17701	16

The three, highest ranked basins in the unweighted ranking, Imperial River - 6, Estero River - 8, and Six-Mile Cypress Slough - 4, are also the three highest-ranked (unweighted) tertiary basins with respect to agricultural runoff discharge, and two of the top three ranked (unweighted) basins with respect to urban runoff discharge. These rankings reflect the size of these three basins, and illustrate why weighted rankings are used for basin prioritization.

The area-weighted rankings of the tertiary basins within the Estero Bay Watershed show that four of the top six ranked tertiary basins in the area-weighted rankings of TSS loadings are within the Hendry Creek Basin, with the remaining two in the top six within the Ten-Mile Canal Basin. The Ten-Mile Canal Basin contains six of the sixteen tertiary basins in the top 25% of the ranked basins. Over 80% of the priority tertiary basins for total suspended solids loading discharges into Estero Bay through Mullock Creek, Hendry Creek, or the Imperial River.

Table 2.3. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for area-weighted TSS loading.

Secondary Basin	Tertiary	Area	%	%	Area-weighted	Rank

	Basin	(acres)	Urban Land Use	Agricultural Land Use	TSS Load (lbs/yr)	
Hendry Creek	6	449	63	7	369.751	1
Hendry Creek	10	2459	59	0	320.463	2
Ten-Mile Canal	7	404	47	0	272.914	3
Ten-Mile Canal	11	2569	42	12	248.316	4
Hendry Creek	8	863	66	7	222.68	5
Hendry Creek	9	517	67	0	219.408	6
Spring Creek	6	545	40	0	215.518	7
Ten-Mile Canal	4	153	67	0	214.992	8
Mullock Creek	4	3596	81	7	207.975	9
Ten-Mile Canal	10	473	26	0	192.86	10
Ten-Mile Canal	9	1266	53	24	183.581	11
Cow Creek	2	1864	61	0	182.725	12
Imperial River	1	3464	61	0	177.331	13
Ten-Mile Canal	5	88	22	0	164.678	14
Imperial River	2	1738	49	2	153.97	15
Estero River	2	72	0	0	150.162	16

2.5 Total Nitrogen Loading

Nitrogen loadings to Estero Bay have probably been affected by agricultural and urban development within the watershed. Changes in land use in the watershed have likely led to increased nitrogen loading to the estuary. Increased nitrogen loading to the estuary, in combination with potential increases in phosphorus loading (described below), can result in eutrophication within the estuary. The Basin Prioritization Report ranked tertiary basins in terms of their potential to contribute nitrogen to Estero Bay. The Prioritization Report analysis provided the area-weighted, priority basins ranking given in Table 2.4.

Table 2.4. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for area-weighted total annual nitrogen loading.

Secondary Basin	Tertiary	Area	%	%	Area-weighted	Rank

	Basin	(acres)	Urban Land Use	Agricultural Land Use	Total Nitrogen Load (lbs/yr)/acre	
Ten-Mile Canal	11	2569	42	12	13.0457	1
Hendry Creek	9	517	67	0	12.0308	2
Hendry Creek	10	2459	59	0	11.7398	3
Hendry Creek	8	863	66	7	11.5284	4
Mullock Creek	4	3596	81	7	11.513	5
Spring Creek	6	545	40	0	11.3219	6
Mullock Creek	5	290	53	0	11.0111	7
Ten-Mile Canal	7	404	47	0	10.6779	8
Imperial River	4	4695	30	37	10.5598	9
Six-Mile Cypress Slough	5	653	14	29	10.3357	10
Estero River	2	72	0	0	10.2914	11
Ten-Mile Canal	10	473	26	0	10.2542	12
Ten-Mile Canal	4	153	67	0	10.0608	13
Imperial River	1	3464	61	0	10.0056	14
Hendry Creek	6	449	63	7	10.0011	15
Hendry Creek	5	1874	27	29	9.7186	16

The area-weighted rankings of the tertiary basins within the Estero Bay Watershed show that the top-ranked tertiary basin is Ten-Mile Canal - 11. Three of the top four high priority tertiary basins are in the Hendry Creek Basin. Fifteen of the sixteen high priority tertiary basins have total-nitrogen loads greater than 10 lb/yr/acre. Fourteen of the sixteen priority tertiary basins for nitrogen loading discharge into Estero Bay through Hendry Creek, Mullock Creek, or the Imperial River.

2.6 Total Phosphorus Loading

Total phosphorus (TP) loading is another factor that has probably been affected by changes in land use and cover in the Estero Bay Watershed. As with nitrogen loading, the conversion of wetlands and forest to urban and agricultural uses increases the potential for phosphorus loading to Estero Bay. This increased loading can increase eutrophication within the estuary. Total phosphorus loading per unit area is typically higher for urban and agricultural land uses when compared to wetlands and other natural land-covers.

Table 2.5 gives the area-weighted relative ranks for annual total nitrogen loading calculated in the Basin Prioritization Report. The area-weighted rankings of the tertiary basins within the Estero Bay Watershed indicate the top-ranked tertiary basin is Cow Creek (7). This is the only tertiary basin within the Cow Creek Basin in the high priority group. Ten-Mile Canal (11) is ranked second for area-weighted total phosphorus loading. All of the top 25% of the tertiary basins have total

phosphorus loads greater than 2 lb/yr/acre. As with other rankings, the majority of the priority basins discharge through Mullock Creek, Hendry Creek, or the Imperial River.

2.7 Point Source Discharges

The number of point source discharges within a secondary basin tends to be related to basin size. There are generally more point source discharges in the larger secondary basins. Over 60% of the known point source discharges is located in tertiary basins that discharge through the Mullock Creek-Hendry Creek outfall or the Imperial River. Table 2.6 lists the number of point source discharges documented in each secondary basin. A more detailed discussion and listing of point source discharges is provided in the Watershed Characterization Report (Volume B of this series).

Table 2.5. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for area-weighted total annual phosphorus loading.

Secondary Basin	Tertiary Basin	Area (acres)	% Urban Land Use	% Agricultural Land Use	Area-weighted Total Phosphorus Load (lbs/yr)/acre	Rank
Cow Creek	7	621	78	4	3.54578	1
Ten-Mile Canal	11	2569	42	12	2.68013	2
Spring Creek	6	545	40	0	2.6564	3
Six-Mile Cypress Slough	5	653	14	29	2.63303	4
Hendry Creek	5	1874	27	29	2.60596	5
Spring Creek	5	88	91	0	2.51201	6
Imperial River	4	4695	30	37	2.49547	7
Mullock Creek	5	290	53	0	2.47242	8
Estero River	7	248	46	24	2.44086	9
Ten-Mile Canal	8	1441	11	42	2.41656	10
Hendry Creek	8	863	66	7	2.38358	11
Spring Creek	3	768	69	0	2.31095	12
Ten-Mile Canal	9	1266	53	24	2.25442	13
Spring Creek	2	868	63	0	2.20255	14
Ten-Mile Canal	6	1728	44	28	2.16375	15
Spring Creek	4	77	46	0	2.02751	16

Table 2.6. Number of domestic and industrial point sources within each secondary basin.	
Secondary Basin	**Number of Point Sources**
Imperial River	33
Estero River	14
Six-Mile Cypress Slough	12
Barrier Islands	11
Hendry Creek	10
Cow Creek	10
Spring Creek	8
Mullock Creek	7
Ten-Mile Canal	7

2.8 Overall Basin Prioritization by Aggregated Criteria

The final product of the basin prioritization effort was to rank tertiary basins according to aggregates of the individual criteria. This process identified the basins expected to contribute the highest levels of freshwater and pollutant loads to the Estero Bay estuary. The basins were first aggregated according to three important criteria representing the potential for excessive freshwater discharge, total suspended loads, and nutrient loads. Each tertiary basin was then assigned an overall rank based on these three important types of potential impacts to the estuary. In the final step, the top 25% of the basins in terms of this overall rank were identified as priority basins.

The ranks for the important classes of criteria were assigned by combining the freshwater and pollutant load estimates developed for the individual criteria and re-ranking the basins with respect to these aggregated estimates described below.

- Total runoff discharge was computed as the sum of the estimated absolute agricultural runoff discharge and urban runoff discharge.

- Nutrient loading priorities were computed as the arithmetic mean of the total-nitrogen load rank and the total-phosphorus load rank.

In the overall basin prioritization, each tertiary basin was assigned an overall rank based on loading impacts. The object of this overall ranking was to identify the areas that should be considered first when developing management options.

The three types of loading (nutrient, total suspended solids, and runoff (freshwater)) are correlated, and they can be attributed to particular anthropogenic activities within the watershed. Excessive freshwater runoff, sediment loads, and nutrient loads all are exacerbated by the creation of impervious surfaces, draining of wetlands, channelization, and clearing of forest and wetland vegetation. As shown in the previous sections, the tertiary basins having the highest runoff discharges are also likely to have the highest sediment and nutrient loads.

Although the geographic distributions of the three classes of impacts are similar, they still respond differently to specific land use practices. Land-use specific sediment loading rates can vary independently from runoff rates depending upon the degree of soil disturbance from tillage, livestock compacting of soils, removal of vegetative cover, and other factors. Land-use specific nutrient loading rates can vary independently from runoff rates according to the degree of grove and cropland fertilization, animal waste production, urban and horticulture fertilization, and other factors.

The tertiary basins of the study area were analyzed with a three dimensional model of freshwater runoff discharge, TSS loads, and nutrient loads, and the overall rank calculated as the mean of the ranks of the three criteria. The tertiary basins within the highest quarter were classified as the highest priority tertiary basins within the Estero Bay Watershed.

The area-weighted, overall rankings of the tertiary basins within the Estero Bay Watershed are listed in Table 2.8. These rankings place Hendry Creek - 10 as the highest priority basin. Three other tertiary basins in the Hendry Creek basin are in the top six ranked tertiary basins. These are tertiary basins 6, 8, and 9. Ten-Mile Canal - 11 is also within the top six ranked tertiary basin, as is Mullock Creek - 4.

As with the individual rankings, the majority of the priority basins in the overall ranking (fourteen of sixteen) discharge through the Mullock Creek-Hendry Creek outfall or the Imperial River. These secondary basins contain the majority of tertiary basins in terms of both number and area (Table 2-8). The prioritization efforts strongly suggest that the Mullock Creek basin complex (Mullock Creek, Hendry Creek, Ten-Mile Canal, and Six-Mile Cypress Slough subbasins) and Imperial River basin should be the primary locations for loading related management efforts.

2.9 Wetlands at Risk

Wetland areas within the Estero Bay Watershed are subjected to the effects of rapid growth and urbanization within the region. These factors create both the potential for changes in runoff and nutrient and sediment loading, and increase the potential for wetland losses. These losses include both the spatial loss of wetlands as well as the ecological degradation of wetland habitats that are not eliminated. The Basin Prioritization Report identified wetlands at risk as wetlands that were valuable habitat but were not protected as public lands or as preserves within approved, large-scale development scenarios like developments of regional impact.

Table 2.10 lists the sixteen tertiary basins with the largest area of wetlands at risk. The results were not area-weighted because the factor in question, wetlands at risk, was only evaluated in terms of spatial parameters. Results indicate that the largest tertiary basins contain the greatest acreages of wetland areas at risk (Table 2.9), with four of the top five high priority basins containing more than 15,000 acres, and the top five high priority basins contain a total of more than 34,000 acres of wetland areas at risk. The majority of this acreage, more than 20,000 acres, is found in the Imperial River - 6 tertiary basin.

Of the five highest ranked tertiary basins with respect to wetland areas at risk, all are also un-weighted analysis, priority basins with respect to total annual phosphorus loading and total annual nitrogen loading, and all but one are also priority basins with respect to total suspended solids loading, urban runoff discharge, and agricultural runoff discharge.

Table 2.7. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for area-weighted overall rank.

Secondary Basin	Tertiary Basin	Area (acres)	Area-Weighted Total Runoff Rank	Area-Weighted TN&TP Loading Rank	Area-Weighted TSS Loading Rank	Area-Weighted Overall Rank
Hendry Creek	10	2459	4	10.5	2	5.50
Hendry Creek	8	863	7	7.5	5	6.50
Ten-Mile Canal	11	2569	14	1.5	4	6.50
Mullock Creek	4	3596	2	12.0	9	7.67
Hendry Creek	6	449	1	23.5	1	8.50
Hendry Creek	9	517	5	14.5	6	8.50
Ten-Mile Canal	4	153	3	18.5	8	9.83
Ten-Mile Canal	9	1266	8	17.0	11	12.00
Ten-Mile Canal	7	404	15	20.5	3	12.83
Imperial River	1	3464	10	22.5	13	15.17
Ten-Mile Canal	6	1728	13	18.5	17	16.17
Spring Creek	6	545	38	4.5	7	16.50
Mullock Creek	5	290	25	7.5	20	17.50
Six-Mile Cypress Slough	5	653	20	7.0	28	18.33
Cow Creek	2	1864	9	34.5	12	18.50
Imperial River	2	1738	24	18.5	15	19.17

Table 2.8. Area of priority basins and percent of total priority basin area within each of the secondary basins.

Secondary basin	Priority tertiary basins within secondary basin	Area of priority tertiary basins (acres)	Percent of summed, priority-basin area
Ten-Mile Canal	5	6120	27%
Imperial River	2	5202	23%
Hendry Creek	4	4288	19%
Mullock Creek	2	3886	17%
Cow Creek	1	1864	8%
Six-Mile Cypress Slough	1	653	3%
Spring Creek	1	545	2%
Estero River	0	0	0%
Barrier Islands	0	0	0%

Table 2.9. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for wetland areas at risk.

Secondary Basin	Tertiary Basin	Area (acres)	% Urban Land Use	% Agricultural Land Use	Wetland Area at Risk (acre)	Rank
Imperial River	6	41568	3	25	20403	1
Barrier Islands	1	15726	13	0	4362	2
Estero River	8	27647	16	27	3970	3
Estero River	6	7467	15	27	2765	4
Six-Mile Cypress Slough	4	18354	20	23	2631	5
Cow Creek	6	3906	2	0	2363	6
Hendry Creek	1	2469	5	0	1605	7
Mullock Creek	1	2973	18	6	971	8
Estero River	1	1278	0	0	898	9
Hendry Creek	2	1139	25	0	601	10
Six-Mile Cypress Slough	2	934	23	3	572	11
Ten-Mile Canal	9	1266	53	24	537	12
Spring Creek	1	2527	35	<1	507	13
Cow Creek	1	810	7	0	504	14

Table 2.9. Relative ranks of the top 25% of the tertiary basins within the Estero Bay Watershed for wetland areas at risk.

Secondary Basin	Tertiary Basin	Area (acres)	% Urban Land Use	% Agricultural Land Use	Wetland Area at Risk (acre)	Rank
Ten-Mile Canal	8	1441	11	42	417	15
Imperial River	4	4695	30	37	403	16